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**Children's acquisition of text search strategies:
The role of task models and relevance processes**

Jean-François Rouet (1), Julie Ayroles (1), Mônica Macedo-Rouet (2), and Anna Potocki (1)

(1) CNRS and Université de Poitiers

(2) University of Paris 8

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Contact: jean-francois.rouet@univ-poitiers.fr

Abstract

Searching texts both online and in print has become an essential skill for 21st century students. Although most children can read fluently and comprehend short texts by the age of 10, research suggests that older students and even adults experience difficulties when searching for information inside texts. This chapter synthesizes various theoretical models of the processes involved in information search, drawing from information science as well as cognitive psychology. We identify three key processes that may represent specific challenges for young students: constructing a task model, selectively scanning, and assessing the relevance of information. We review the evidence regarding children's ability to search for information, and we stress the importance of the task model on subsequent search processes. In the last part of the paper, we review attempts to foster children's information search skills and we highlight some preconditions for skill acquisition. Finally, we discuss the implications of research on children's search skills for future research in this domain.

Keywords

acquisition, comprehension, instruction, memory, reading, search, self-regulation, strategies

Information search is a prevalent mode of interaction with printed and digital texts. From the elementary grades on, teachers assign tasks that require students to use texts in order to locate information of interest (Armbruster & Armstrong, 1991). Adults most often engage with texts in order to locate information as part of purposeful activities such as locating factual information, finding solutions for a problem, or making informed decisions (Britt, Rouet, & Durik, 2018; White, Chen, & Forsythe, 2010). Although pervasive, information search is a challenging activity not only for children but also for older students and adults (Macedo-Rouet, Rouet, Ros, & Vibert, 2012). Extensively documented difficulties range from not knowing exactly what or how to search, to selecting inadequate documents or portions of documents, to not finding the target information even though it is actually there, to making ineffective use of the information. Effective search skills are arguably the outcome of students' experiences with purposeful reading in and out of school, during primary and secondary education (for the more advanced search skills that may come as an outcome of higher education and domain specialization, see e.g., Khosrowjerdi & Iranshahi, 2011; Vibert, Ros, Le Bigot, Ramond, Gatefin, & Rouet, 2009). Therefore, in order to understand adult users' challenges when searching for information, it is important to understand how search skills develop throughout childhood and how they may be influenced by education.

The cognitive processes underlying information search have been examined from various perspectives. Information scientists have described the processes and stages that are generally involved in an information search situation (Belkin, 1993; Kulthau, 1991; Marchionini, 1995). Behavioral research has examined the cognitive processes actually brought to bear by individuals as they search, how these processes may change as a function of individual development, learning, but also the demands of particular contexts and tasks (Britt, Rouet, & Durik, 2018; Rouet, 2006; Wellman, 1985). Nevertheless, research into children's acquisition of information search skills has been relatively scarce.

The present chapter seeks to contribute to a multidisciplinary approach to information search by focusing on children's acquisition of information search skills and how these skills relate to cognitive development and educational practice. More specifically, our goal is to propose a framework for understanding the challenges children face when searching printed or digital texts, and how these challenges can be addressed. We believe that such an understanding can provide insights into the design of effective instructional situations and computer tools. Our definition of information search encompasses any situation in which the person engages with printed or digital texts based on a specific need, purpose or goal in mind. We focus on searching information within texts, as opposed to other types of information resources or media, in order to highlight the specific challenges that come with reading in the context of search tasks, especially for children. We also focus on studies conducted with children between the ages of 7 and 12 (see Hahnel, Goldhammer, Kröhne, & Naumann, 2018, or Salmerón, García, & Vidal-Abarca, 2018, for examples of studies involving older students; see also Salmerón, Strømsø, Kammerer, Stadler, & van den Broek, 2018, for a more general review of online reading).

The chapter is organized into three main sections. In the first section, we review various theoretical approaches to information search, and we propose a unifying framework to identify the critical stages and processes that may represent particular challenges for children. This framework emphasizes the role of the "task model", or the person's understanding of their task and goals. The framework serves as a structuring scheme for the following two sections. The second section reviews the extant research devoted to children's challenges when searching information in texts. The third section examines some attempts to foster search skills through either general or specific interventions. We conclude with some directions for future research in this area, both from a cognitive and an information science standpoint.

1. Information search as a complex skill

Searching for information is a pervasive but complex kind of behavior. Information searchers need to know what they are searching for (i.e., their goal); they need to be aware of the available information sources and of the means available to access information (i.e., a query tool); they need to make decisions as regards source(s) they encounter; they need to actually query or browse through the source, and to decide when the information found matches their needs. Finally, searchers need to decide when the information gathered is sufficient to satisfy their goal, considering available time, subjective importance of the task, other potential sources available and likelihood of obtaining better outcomes. Over the past three decades, scholars from various academic disciplines (e.g., information

science, psychology, computer science) have attempted to describe these processes. In this section, we review a few of these attempts in an effort to identify the core overlapping constructs and to organize them into a unifying framework. Note that our ambition is not to provide an exhaustive review of information search theories, but rather to show how different theories converge toward a common set of key constructs.

1.1. A brief review of information search models

Early works rooted in the library and information sciences have proposed broad descriptions of information seeking considered from the point of view of the "user" (e.g., Belkin, 1993; Kuhlthau, 1991; see Savolainen, 2018, for a recent discussion). Kuhlthau's (1991) seminal model of the Information Search Process (or ISP) identified the cognitive and affective states that users generally experience as they engage in information activities. According to Kuhlthau, information search involves six stages: initiation (or acknowledging one's information need), selection (defining a topic or an approach), exploration (broad examination of the resources based on an ill-defined goal), formulation (defining a more focused perspective on the topic of interest), collection (acquisition of information on the focal topic), and presentation (or making use of the search outcomes). Kuhlthau proposed to link specific affective states to each of these stages, with for instance exploration being associated with frustration or doubt, whereas formulation would come with a sense of "clarity". Like Kuhlthau, Belkin (1993) challenged a dominant approach at the time, which assumed that the information need of users querying an information system was relatively static and accurately represented in their queries. Belkin's "berrypicking" model assumed that searchers gather information one piece after the other and refine their information needs *en route* as they hit (un)satisfactory results. She also pointed out that people use a broad range of strategies when searching information, with querying being only one of them. For instance, information searchers may direct themselves to particular areas in a library, look for particular authors, or scrutinize particular sections of a document in order to find references. These strategies are based on people's experience with some search domains but also information environments and tools (Marchionini, 1995). The opportunistic, iterative nature of information search was further stressed in later works such as the "information foraging" theory (Pirolli & Card, 1999). Information foraging sees the "optimal" searcher as a person who "seeks to maximize the rate of information gained per unit cost" (p. 5), given the constraints of the task environment." Their ACT-IF model assumed that information searchers are guided by signals (such as headers or summaries) that provide cues as to where the information of interest may be located and how to get it. They provided support to the model through a series of case studies of adult, rather well-educated users interacting with specialized information repositories. More recently, Agarwal (2018) proposed a model that stresses the role of "context" in information searching, with the view that information behavior depends on a number of circumstantial variables. He builds on previous conceptualizations of context (e.g. Rieh, 2004), to stress the need to identify specific contextual factors that influence searchers during the information search process. Similarly, Savolainen (2018) reviewed key models of information seeking as temporal developments, and proposes a new model that reconciles the perspectives of stage-based and cyclic models of information seeking.

Meanwhile, research stemming from cognitive and developmental psychology has also attempted to understand the processes involved in text and document search, although with a different perspective. Information search was considered a specific reading strategy, to be contrasted with the sustained reading of continuous texts for comprehension. Thus, early research in that area has attempted to account for the selective reading of texts under specific task contexts. Guthrie and his colleagues proposed that locating information in text involves processes that are cognitively distinct from reading for comprehension. Guthrie (1988) described five core processes involved in text search, namely (a) form a goal, (b) inspect categories of information in the text, (c) detect and extract relevant details from each category, (d) integrate the information with prior knowledge and the goal, and (e) recycle steps 1-4 until the goal is achieved. Although processes a), d) and e) may also be found in other reading activities, processes b) and c) did not match any of the cognitive models of reading comprehension available at the time. Guthrie and Kirsch (1987) found that comprehending technical articles and locating information in articles or in schematics constituted two independent proficiency factors in a group of electrical technicians and engineers. Guthrie and Mosenthal (1987) listed a number of features that distinguished locating information from other constructs such as problem solving, reading comprehension or studying. For instance, in contrast to reading comprehension, locating information does not require the reader to memorize the contents read, but it does require the reader to make decisions regarding which parts of the documents to inspect (and which to ignore). Guthrie and Mosenthal further conjectured that locating information may not depend so much on

readers' prior content schemata, but rather on their acquisition of "procedural" schemata regarding the typical organization of information in documents.

Although Guthrie and his colleagues' early work was primarily designed to account for the specific task of locating information in printed documents, their theoretical insights resonate in more recent descriptions of students' interactions with complex information systems, such as Brand-Gruwel, Wopereis, and Walraven's (2009) model of information problem-solving on the Internet (IPS-I) or Goldman *et al.*'s (2010) model of multiple source comprehension. Brand-Gruwel *et al.* (2009) IPS-I model includes five core processes, namely: define the information problem, search, scan and process information, and organize and present information. These processes are assumed to rest on three types of foundational skills: reading, evaluating and computer skills. Finally, the IPS-I model also considers the cognitive regulation mechanisms that control the "flow" of search processes. Regulation involves planning (i.e., setting goals and anticipating the actions to be carried out), monitoring, steering and evaluating the outcomes of one's actions. A distinctive feature of the IPS-I model is that it acknowledges the flexibility of reading processes by contrasting scanning vs. deeper (integrative) processing of a page content. In addition, the model stresses the importance of both lower-level processes (e.g., literal comprehension) and higher-order, metacognitive processes (monitoring, evaluating). Other researchers have emphasized the links between the search and comprehension of information, on the one hand, and the transformation and communication of that information, on the other hand. Goldman and her colleagues (2010) proposed a framework for analyzing students' multiple-source comprehension, in which they defined a source as "any form of information that a person is able to process or use" (p. 261). They postulated a process model with five main components: Interpret the task; Search for or gather resources; Use information about the source to inform the selection process; Analyze and synthesize the resources; and Apply the resources (with the latter involving a decision about which resource is most appropriate for the task at hand). The latter process emphasizes the fact that comprehension often involves making use of information to address the demands of the tasks. Application may require the reader to transform information found in a source and/or to combine it with information found in another source. In their perspective, texts are not the "building blocks" of comprehension, but rather resources from which readers may draw as a function of their adequacy to the task at hand. Leu and his colleagues (2013) similarly highlight the importance of transforming information as they list four core skills that are focused on in their ORCA assessment of Internet literacies. These skills include: locating and evaluating information, but also synthesizing and communicating the outcomes of one's research. The generalization of online reading has prompted further efforts to bridge general and more analytic approaches. For instance, Salmerón, Strømsø, Kammerer, Stadler and van den Broek (2018) proposed three core competencies specifically involved in Internet reading, namely navigation (i.e., which sources to access and in which order), integration (i.e., comprehending information within and across Web pages), and evaluation (i.e., assessing the relevance and trustworthiness of information).

Both the early models of locating information and more recent models of complex information activities stress the importance of tasks and goals. Vakkari (2003) noted that meaning acquired from text is mostly a function of readers' information goals and needs, combined with their prior knowledge. McCrudden and Schraw (2007) examined the demands of various types of instructions that students may receive prior to engaging with text. Based on a review of research into the role of reading standards and goals, they proposed that "relevance instructions" drive readers' attention to relevant parts of texts and determine the appropriate level of processing of content information. It is important to note that in McCrudden and Schraw's perspective, relevance instructions do not necessarily involve the search and extraction of specific information from text. Instead, their framework encompasses specific and general types of instructions, which they argue call for specific types of reading strategies. Rouet (2006) and Rouet and Britt (2011) further specified the processes whereby the reading task context may influence reading decisions and processes. The MD-TRACE model (Multiple-document task-based relevance assessment and content extraction; Rouet & Britt, 2011) posits that readers interpret task instructions and other features from the context in order to set reading goals. Thus, given a context and a set of instructions, readers' search behavior is likely to vary as a function of their individual understanding of the context. More recently, Britt *et al.* (2018) suggested that readers' relevance decisions are driven by their understanding of the context including, but not limited to, task instructions. Thus, readers may make different decisions based on, for instance, how much time is available or whether the task involves high or low stakes. Readers' individual task model also determines readers' extraction of information from texts and their actual use of the information in their task product.

1.2. Three specific cognitive demands of information search.

Put together, the works reviewed above consistently emphasize three critical demands of information search: (a) The need to information users to understand their task and to generate and update their search goals accordingly (b) The need to use proximal and distal cues in order to access information of interest while minimizing the time spent processing irrelevant information; (c) The need to assess the adequacy and sufficiency of information with respect to the end goal and/or product. Table 1 provides a summary of how these demands match some of the descriptions reviewed above. Table 1 also briefly specifies how these demands differ in search tasks compared to plain reading comprehension task. The reference to reading comprehension is helpful to identify potential gaps in current educational programs and methodologies, which are clearly centered in the latter construct.

Table 1. Three core demands of information search and how they differ from reading comprehension.

	Correspondence with past frameworks	Contrasts between search and reading comprehension tasks
Form a task model	"Initiation", "Formulation" (Kuhlthau, 1991) "Form a goal" (Guthrie, 1988) "Define the information problem" (Brand-Gruwel <i>et al.</i> , 2009) "Interpret the task" (Goldman <i>et al.</i> , 2004) "Form a task model" (Rouet & Britt, 2011)	Text comprehension may be considered a generic task whereby the reader seeks to construct a mental model of the situation described in the text (Kintsch, 1998; but see van den Broek <i>et al.</i> , 2011). In contrast, each search task calls for a specific task model based on the external specifications of the task and/or on self-generated goals.
Select information of interest	"Selection", "Exploration", "Collection" (Kuhlthau, 1991). "Inspect categories of information" (Guthrie, 1988) "Search, Scan" (Brand-Gruwel <i>et al.</i> , 2009) "Search for/gather resources" (Goldman <i>et al.</i> , 2004) "Locate and evaluate" (Leu <i>et al.</i> , 2013) "Selection, Extraction, Integration" (Rouet & Britt, 2011)	In a typical text comprehension setting, information is read in the text order of presentation. The position of information in readers' mental model reflects a hierarchy of structural importance in the text; in a search task, the reader focuses on portions of the text(s) that are relevant to the task, disregarding any other information irrespective of their structural importance (see e.g., McCrudden & Schraw, 2007).
Assess information with respect to task product	"Presentation" (Kuhlthau, 1991) "Apply the resources" (Goldman <i>et al.</i> , 2004) "Synthesize and communicate" (Leu <i>et al.</i> , 2013) "Create/Update a task product" (Rouet & Britt, 2011)	As a product, text comprehension is achieved when the reader has processed the text entirely. In a search setting, the reader has to decide whether to use the information and whether additional texts are required.

As shown in Table 1, the processes of forming a task model, selecting information of interest and assessing the information with respect to the task goal or product were identified in most earlier models of information search under various but consistent wordings. In addition, they emphasize the sharp contrast between reading for comprehension on the one hand, and using texts (or information systems) for specific purposes, on the other. Finally, this synthesis stresses the importance of constructing and revising goals (e.g., forming an adequate task model). Neither the selection nor the

assessment of information acquired may be achieved without an adequate representation of the task. We believe that this prominence of the task model may explain some of the difficulties observed in children and teenagers as they engage in information search as part of learning activities.

In the rest of this chapter, we examine children's acquisition and use of these processes. In the next section, we review existing research on children's challenges when searching information in texts. Then, we examine researchers' attempts to design interventions that may support children's acquisition of better search skills.

2. Children's challenges with information search: task model construction, selective access, and relevance assessment.

A child is broadly defined by the World Health Organization as a person 19 years or younger (WHO, N.D.). For the purposes of this chapter, we will focus on studies conducted with children between the ages of 7 and 12. As stated earlier, children experience the need to read texts selectively in order to identify specific pieces of information very early in school curricula (Armbruster & Armstrong, 1993; Rouet & Potocki, 2018). Early research has evidenced that reading in order to locate specific information is a challenge for students in the elementary grades (Armbruster & Armstrong, 1993; Kobasigawa, 1983; Kobasigawa, Ransom, & Holland, 1980; Raphael, 1984). More recently, international large-scale studies such as PIRLS have found that searching in a text is not any simpler for 4th grade students compared to, for instance, identifying the main idea of a passage (Mullis, Martin, Foy, & Hooper, 2017). The PISA study has provided additional evidence that searching and integrating information from different paragraphs is a challenge even for fifteen-year-old students (OCDE, 2013).

The challenges of searching texts, both in print and online, may be examined in light of the broad conceptual framework outlined in the first section of this chapter. The first challenge is to *gain an adequate understanding of the task demands* (form a task model); the second challenge is to *make decisions regarding which information to focus on* and which information to skip or ignore (Select information of interest); and the third challenge is to *determine the adequacy and sufficiency of information given the task objectives*. The latter challenge amounts to being able to decide when one may quit reading vs. recycle through earlier steps in the search process (see Guthrie, 1988). It thus requires some monitoring of one's progress toward the end goal.

In the rest of this section, we review extent research into children's performance and challenges related to these three core components of search.

2.1. Challenges in understanding and remembering the search task.

A task model is a mental representation that includes one's interpretation of the task statement (e.g., a search question), but also the expected outcome of the search (i.e., the expected task product) and some initial action to be performed (i.e., an initial subgoal; Rouet & Britt, 2011; Britt et al., 2018). To illustrate the challenge of forming a task model, imagine a middle school student who is studying the spread of epidemics and how to prevent them. This student is asked to find out "*When should a traveler start taking medication in order to prevent malaria?*" Constructing a task model involves understanding what the question is asking. According to Graesser and Franklin's (1990) QUEST model, understanding a question involves categorizing it (in this case, a "when" question) and identifying what the question is about (in this case, taking a medication in order to prevent malaria). Identifying the question focus amounts to constructing a mental model of a situation. The situation may range from a simple object, character or fact, to a complex causal explanation. The task model also involves generating an initial action to be performed, for instance *Locate information that looks like it is a date or a period*. Researchers have acknowledged the importance of building an accurate mental model of the task in functional reading (Goldman & Durán, 1988; McCrudden & Schraw, 2007; McCrudden, Magliano, & Schraw, 2010). Indeed, the chain of decisions and processes that unfold during search depends on the searcher's understanding of what the search is about. Moreover, readers have to keep their task model in mind throughout the search, as they examine various texts and sections within texts. Some studies have already pointed the complexity of such construction for readers (Rouet 2003; Vidal-Abarca, Maña, & Gil, 2010). However, most of these studies have focused on teenagers (i.e. 13-19 years of age) and young adults (i.e., older than 19 years of age; WHO, N.D.)

Among the few studies targeting younger students, Vidal-Abarca *et al.* (2010) analyzed the self-regulation processes present in task-oriented reading activities of skilled and less skilled

comprehenders at the 7th and 8th grades (13-15 years of age). Using an error detection paradigm (Hannon & Daneman, 2004), they introduced inconsistencies within questions (e.g., *When should treatment begin to **cause** malaria? NB. Emphasis added*) and asked participants whether the questions could be answered using text information. The probability for a reader to say that the question could not be properly answered was higher for skilled than for less skilled readers. The authors speculated that skilled readers are more able to integrate several ideas contained in the question and, thus, to detect a potential contradiction (e.g., between *treatment* and *causes of malaria*). Similar results were obtained by Cerdán, Gilabert and Vidal-Abarca (2013). They asked 40 9th graders to explain search questions by rewriting them with their own words. Skilled comprehenders included a higher number of bridging inferences, and less-skilled comprehenders included a greater number of incomplete and wrong ideas in their answers. These results indicated that less-skilled comprehenders had built an incorrect and incomplete representation of task demands, which in turn deteriorated their comprehension performance.

Developing readers may also have difficulty remembering the demands of a search task as they selectively scan documents. Potocki, Ros, Vibert and Rouet (2017), found that 5th graders' (9-10 years of age) performance depends on the cognitive demands of the search question. Questions that required the comparison of several paragraphs (i.e. integration questions) generated longer search times and more errors than location questions. Also, integration questions generated more incomplete answers, which suggests that children sometimes partially forgot the question during their search. This hypothesis is consistent with Rouet and Coutelet (2008) who observed that many 3rd graders tended to forget the question during a search task involving an encyclopedia. Finally, Potocki *et al.* (2017) noticed that the participants in their experiment sometimes answered a different but related question instead of the one they had been asked. In those cases, the initial question was often simplified (e.g., "*What is the highest mountain?*" instead of "*Which are the two highest mountains?*"). Thus, it is also possible that children's memory for the question gets distorted during the search.

In sum, cognitive and developmental research has found that one of the core difficulties children experience when searching for information is the construction and maintenance of an accurate task model. This line of research fully corroborates early researchers' claims that a person's goal when searching should not be equated with the task they were assigned or the query they articulate (Belkin, 1993; Kuhlthau, 1991). Instead, search goals are the outcome of a constructive process whereby individuals examine cues from the context and the task instructions (when available) and derive a representation of the task product and the means needed to generate that product (Britt *et al.*, 2018).

2.2. Challenges in selectively accessing content information.

Another challenge of information searching in texts is the requirement to access relevant information rapidly and efficiently, without wasting processing effort and time with irrelevant pages or paragraphs. Contrary to text comprehension, information search does not always demand the construction of a broad representation of the text's meaning. Instead, the aim is to gather the information needed to answer a question. To this aim, the use of metatextual cues such as titles or links in a menu is an effective strategy for finding information. The problem is that until the end of elementary school children's knowledge of metatextual cues seems to be rather limited. (Garner, Alexander, Slater, & Hare, 1986; Eme & Rouet, 2001).

Garner *et al.* (1986) probed children's metatextual knowledge by asking 3rd, 5th and 7th graders to complete a series of paragraph-construction tasks. Almost all of the participants were able to identify paragraphs in the text and group topically related sentences together to make short texts. However, only the 7th graders were able to describe what makes a paragraph and none of the participants could appropriately formulate the main idea of a paragraph through a formal title. These results were partly replicated by Eme and Rouet (2001). In their study, participants demonstrated good knowledge of what a title or a paragraph are, but only a few students could tell the purpose of such devices. Hence, the children had knowledge of the "structural" aspects of texts, but not of the "functional" aspects of meta-textual cues. These results suggest that the acquisition of meta-textual knowledge is a prerequisite for locating relevant information in texts (Potocki *et al.*, 2017).

Even though they may possess some knowledge of meta-textual cues, children may be challenged by the use of such cues during information searching. For instance, for the question "*What do marine crocodiles eat?*", it is highly likely that the answer may be found in a paragraph titled "*What marine crocodiles eat*" or even "*Feeding in marine crocodiles*". Most readers are able to identify such paragraphs thanks to a literal matching between the key-words *marine crocodiles* and *eat/feeding*.

However, when the link between the question and the title is not explicit, inferential matching is necessary. In this situation, readers need to infer the relevance of a paragraph by comparing mentally implicit title content with their understanding of the question, that is, their task model. A study by Kobasigawa (1983) illustrated how this task is challenging for children. In response to the search question "*I want to find out why China cannot produce enough food even when many people are working on farms*", 4th graders restricted their keywords to *farming* and *food*, while 8th graders provided additional key-words (e.g., *population*, *climate* and *soil*).

Dinet, Passerault and Rouet (1998) examined the use of metatextual cues by 8-10 year olds and adults in a simulated Internet environment. Participants had to select five titles that seemed relevant for a search on "the role of peasants in the French Revolution", from a list of 24 items. Relevance was manipulated through the semantic adequacy of the reference (i.e., adequate / inadequate), typographic marking (i.e., keywords in regular typeset or in capitals), and the number of relevant keywords in the reference. Children were more prone to selecting inadequate references than adults. In addition, the probability for children to choose an irrelevant reference increased when the reference contained two descriptors and/or if this reference included capitalized keywords. Dinet and colleagues concluded that younger learners tend to assign relevance based on visual cues (e.g., capitals, boldface type...) rather than on the semantic relation between the reference and the topic. These results are consistent with Rouet, Ros, Goumi, Macedo-Rouet and Dinet's (2011) study showing that 5th and 7th graders' Web menu selection strategies were strongly influenced by superficial relevance cues. In a subsequent study, Dinet *et al.* (2010) recorded 5th graders' eye movements while they were exploring a list of Web links. They identified four visual strategies: (1) A F-shaped scanning pattern whereby information at the top and/or to the left of the page was more likely to be fixated; (2) The visual scanning of whole Web pages (or "exhaustive" strategy); (3) A simple visual detection strategy (i.e., skimming from key-word to key-word); (4) A reversed F-shaped strategy (i.e., similar to the F-shape but with a deeper examination of the bottom of the page). In echo with evidence regarding the influence of superficial cues on children's search, the results also show that children use mostly a simple visual detection strategy, especially if the words are typographically marked (here, in bold). Hence, using meta-textual cues efficiently is more complex than just knowing their definitions and functions, and may represent a serious barrier for children until the end of elementary school.

Some studies have highlighted the effect of comprehension skills on students' ability to inhibit distracting information from the text. In a study by Cerdán, Gilabert, and Vidal-Abarca (2011), 14-year-old students had to read two texts and answer questions. Half of the questions had been manipulated to create a misleading matching between the wording of the question and distracting pieces of information in the text. Participants were characterized as skilled or less-skilled based on standardized test of reading comprehension. Skilled comprehenders were more able to discard the distracting information compared to less-skilled comprehenders.

Taken together, these results suggest that younger or less skilled comprehenders tend to consider superficial cues in their task model as valid, whereas older readers or skilled comprehenders tend to match the search question and the text contents based on deeper semantic processing. Indeed, Cataldo and Cornoldi (1998, experiment 2) highlighted the importance of children's reading comprehension strategies, including when selectively scanning texts. They compared the ability of 6th-7th grade poor and good comprehenders to use strategies in order to answer comprehension questions. Contrary to the control group, the experimental group was explicitly invited to search through the text and to underline with different colors the sentences necessary to answer each question. This manipulation resulted in an increase in search performance. Therefore, children's difficulties seemed to be due to a lack of effective use of strategies rather than an inability to search for relevant information in a text *per se*. A related study by Kobasigawa *et al.* (1980) explored the spontaneous use of skimming strategies by 4th, 6th and 8th graders. They found that children were able to skim but only when explicitly asked of do so. These results are in line with Dreher and Sammons' (1994) study exploring the use of structure indicators (e.g., index, table of content) by 5th graders in an information search task. Most of their participants were able to define the structure indicators but did not use it unless they were prompted to do so (through guiding questions before and during the task). Indeed, prompting increased the likelihood that a child would use the index, and index use greatly improved the chances of locating the answer. Moreover, several studies reveal that spontaneous use of content cues as a strategy to locate specific information develop gradually with age. For example, Kobasigawa, Lacasse and MacDonald (1988) compared the use of titles in an information search task for 4th, 6th and 8th graders. The results showed that the spontaneous use of the titles does appear in half of the 4th and 6th graders and in all the 8th graders. However, even in the 8th graders, this

spontaneous use does not intervene at the beginning of the task but is set up little by little during the search for information.

More recently, Rouet and Coutelet (2008) also showed that information retrieval strategies evolved according to grade level (3rd, 5th and 7th). Indeed, 3rd graders ran the text from top to bottom, not seeming to use text organizers, contrary to older students who were the ones who used the most textual cues (table of contents, index) while searching for information. Thus, top-down strategies, based on the examination of headings and keywords appeared only at grades 5 and 7. However, even for the older ones, searching the relevant information to answer a question in a text was still a difficult activity. These developmental trends are consistent with Dreher and Guthrie's (1990) study showing that more efficient 11th graders were quicker than less efficient ones thanks to their use of content cues, especially when task complexity increases. Indeed, they spent more time, in the first phase, to select relevant units through the index, glossary, table of content of a chapter (presented on a computer screen) allowing them, in the second phase, to localize and extract faster the information needed. Moreover, Rouet and Coutelet (2008) examined the relationships between search performance and strategy use and found that the acquisition of efficient search strategies is linked to students' awareness and use of text organizers. Finally, Potocki *et al.* (2017) examined children's use of headings when scanning a document to answer a specific question. Twenty-six French 5th graders were asked to search relevant information in a text in order to respond to questions while their eye movements were recorded. Potocki *et al.* (2017) analyzed their visual scanning patterns based on the type of transition between areas of interest: title-to-title transitions or paragraph-to-paragraph transitions. They assumed that title-to-title transitions reflect a top-down strategy whereas paragraph-to-paragraph transitions reflect linear reading. The use of a top-down strategy resulted in shorter response time than linear reading. However, Potocki *et al.* observed strong differences between children. Some fixated titles systematically while others never used them. Interestingly, and in line with the results of Rouet and Coutelet (2008), these differences were more strongly related to participants' knowledge of text features reading strategies than to their reading-comprehension abilities. Hence, good decoding and understanding are not enough to mobilize effective strategies but seem to be more related to the metaknowledge as well as the quality of the task model.

In sum, children who learn to search of information need to generate search criteria and match them with the information available in the environment. This is best done by focusing on content organizers and other meta-textual cues that will yield the strongest "scent" with respect to one's task model (Pirolli & Card, 1999). Until the end of primary education, however, students have limited metatextual knowledge and do not seem to know how to use it effectively. From Grade 5 on, readers seem to gradually acquire knowledge about the functions and uses of meta-textual cues (e.g., titles, menus, links). It would therefore be interesting to examine more closely the spontaneous use of these content cues during an information search task. Even if metatextual knowledge increases with age and education, most 7th or 8th graders do not seem to use it spontaneously in the service of information search. Moreover, students tend to use the available cues in a superficial way, perhaps due to their inadequate representation of the task demands.

2.3. Challenges in assessing the relevance and quality of information.

Based on the construction and the maintenance of a task model, as well as on the use of search strategies (*i.e.*, use of content cues), readers have to determine whether the information is adequate and sufficient to achieve the reading goal.

Examining the adequacy of information is not a trivial task for children when they search for information in a text. Cataldo and Cornoldi (1998) found that 6-7th graders with poor comprehension could acknowledge when their answers to comprehension questions were inadequate (through confidence ratings after each question) but, interestingly, this awareness did not improve their performance. Thus, poor comprehenders did not use spontaneously reading comprehension strategies and making more explicit the awareness of low comprehension seemed to be insufficient to promote an activation of more efficient strategies. Hence, poor comprehenders were able to monitor their comprehension and identify the inadequacy of their answer but could not overcome that difficulty. In the study by Kobasigawa (1983), the participants (4th and 8th graders) had to read another student's research report and evaluate how well it answered three specific questions. In general, the younger children were not sensitive to the need to evaluate the adequacy and sufficiency of the answer according to the question. However, when the experimenter explicitly asked if the information reported answered to a specific question, the 4th graders were able to state correctly if the report did not include all required information. Therefore, 4th graders appear to have the ability to recognize what constitutes

appropriate solutions to search tasks, but they often fail to use it spontaneously to evaluate the quality of answers. More recently, Potocki *et al.* (2017) proposed that the difficulties of children could be linked to their low level of monitoring while searching the text. In their experiment, even though participants were given the possibility to ask the question again while searching for an answer in the document, few of them did use this opportunity. The authors suggested that readers who have a better task model might know what they are looking for and can ask the question just to make sure they answer it correctly (Rouet & Britt, 2011).

Children might also lack self-regulation strategies that are necessary to the assessment of sufficiency of information. Vidal-Abarca *et al.* (2010) examined 7th and 8th graders' self-regulation of the search process by calculating (a) the percentage of time spent reading relevant information during the question-answering process over the total time spent reading all information and (b) the number of times a student answered the question immediately after reading a relevant piece of text. In two thirds of the cases, when skilled readers decided to search, they found a segment with relevant information, and they then immediately gave an answer based on the relevant information just read. In contrast, less skilled readers adopted the same search behavior less than half of the time. Vidal-Abarca *et al.* did not find significant differences between skilled and less-skilled readers in the distribution of search time, but the observed differences were in the predicted direction.

Finally, children may also be challenged by other dimensions of information evaluation such as the assessment of source reliability. Coiro, Coscarelli, Maykel, and Forzani (2015) asked 7th graders to locate and evaluate reliable websites in a web-like database. Although most students correctly identified source information, such as the author's name, only 31% provided a clear yes/no answer to whether the author was an expert, and 51% failed to cite any specific criteria for expertise. Thus, one's ability to locate information does not necessarily mean that one can interpret that information properly. Similarly, Paul, Cerdán, Rouet, and Stadler (2018) found that 4th graders could successfully identify source information and evaluate informants' expertise and intentions in simple search tasks, but failed to apply this ability to more complex and implicit tasks. Moreover, Dreher and Guthrie (1990) showed that monitoring and determining the adequacy and sufficiency of information is challenging even for older students. In their study, high school students had to locate information in a textbook chapter in order to answer questions. The results showed that 14 of 31 participants answered incorrectly. Among those, 8 went to at least some of the correct pages but failed to extract the relevant information. Such results illustrate that less efficient text searchers' struggle to assess adequacy of information with respect to the task demands.

Put together, the studies reviewed in this section illustrate the difficulties of children and adolescents in addressing the challenges of information search. Research suggests that many children struggle to construct and maintain a detailed and effective task model in memory. A poor task model may impact their ability to select information adequately and to monitor their attainment of the reading goal. Additionally, the studies point out the critical importance of self-regulation in initiating, monitoring and regulating the search activity (Brand-Gruwel *et al.*, 2009). Finally, although several studies highlight the improvement of search strategies with age and schooling, the same studies point to the uneven acquisition of these strategies among children at any given grade level. Thus, it would seem important to implement some explicit teaching of functional reading skills as soon as students have acquired basic reading skills, that is to say from Grades 3-4 on (Macedo-Rouet *et al.*, 2013).

3. Fostering readers' search skills

A large number of studies have attempted to teach reading strategies using various instructional approaches (e.g., National Reading Panel, 2000; Palincsar & Brown, 1984; Paris, Cross, & Lipson, 1984). However, as Ng and Graham (2017) have quite rightly pointed out, these interventions have generally been conducted within the framework of single text comprehension (e.g., one reader reading one text for the general purpose of comprehension). On the contrary, very few studies have focused on functional reading situations, such as searching for specific information in texts or critically assessing the reliability of information. In the more recent period, researchers have begun to address these more advanced literacy skills. Consistent with the scope of this chapter, we will focus here on studies conducted with children.

Using the same framework as in the previous sections, we discuss 1) interventions proposing pre-search activities in order to enhance students' task model (understanding the task and implementing an adequate strategy); 2) interventions focused on the purposeful reading of documents and in particular, on relevance or reliability evaluations; and 3) interventions combining different

stages of the information search processes. We then discuss some perspectives these studies afford for the development of efficient programs to foster children's functional reading skills.

3.1. Interventions using pre-search activities to enhance readers' task models.

As discussed earlier in this chapter, models of information search emphasize the importance of having an adequate mental model of the task. For example, students need to develop an accurate understanding of what the question is asking for, and to anticipate the target information they have to find in the document(s). A few studies have tried to develop interventions focusing on students' construction of a task model prior to their engagement in the actual search process.

Coutelet and Rouet (2004) proposed an intervention to enhance 3rd and 5th grade students' search skills by means of a series of guided training tasks following a three-stage model called Evaluation-Selection-Processing (Rouet & Tricot, 1996). Training tasks focused on making the children reflect on their objective when searching, and on the way they can locate relevant information in relation to this objective, in particular, by taking into account metatextual cues such as headers and introductions. The participants took part in small group activities 30 minutes per week over a five-week period. Their performance on a criterion search task was evaluated before and after the training sessions and was compared to that of a control group (performing only reading tasks during the training sessions). A medium-term effect was also tested with a delayed post-test administered one month after the end of the intervention. The intervention had no overall effect on participants' search speed nor correct responses (but the authors reported a ceiling effect in terms of correct response with an error rate of just 1%). However, by distinguishing different types of strategies used by the children when searching (Cataldo & Oakhill, 2000), they observed that in the delayed post-test, 3rd grade children from the experimental group no longer used low-level strategies (i.e., linear reading of the whole text from top to bottom), whereas 20% of the control group children still used them. Conversely, trained children used more elaborated strategies (i.e., use of titles and subtitle to access the relevant information) than the control group children (43,75 % versus 15 % respectively) after the intervention. Such effects were not observed in older readers in grade 5 for whom the authors reported no differences between the experimental and the control group.

De Vries, van der Meij, and Lazonder (2008) examined the influence of pre-search activities as a means to promote "reflective" Web search in 5th and 6th graders. More specifically, they conducted a study in which they trained children to use an experimental portal and a worksheet when they were searching information on Internet. The portal consisted in a pre-selection of websites for biology topics (e.g., design of bees' or ants' communities) presented in a structured way. They also provided the students with a worksheet inciting them to write down their search questions and to note their results. In this worksheet, the authors also provided (in Experiment 2) a specific space inviting the children to explicate their prior knowledge on the topic and the potential answer to the question that can be derived from their previous knowledge before carrying out the actual search. Qualitative analysis of worksheet contents and other qualitative observations indicated that the method was actually beneficial. First, the portal seems to have helped children to locate relevant information more efficiently, suggesting that narrowing the search space and categorizing information might be beneficial for them. Second, the worksheet used in this study seemed to help children to stick to their question, to pre-activate relevant knowledge on the topic and in doing so, was beneficial in terms of information search outcomes. This study however did not include any control condition making it difficult to conclude about the specific impact of this intervention.

Using a different procedure, Rouet, Ros, Goumi, Macedo-Rouet, and Dinet (2011, Experiment 2) attempted to foster students' selection of items in a simulated search engine menu by proposing a pre-search activity to students in grades 5 and 7. In this study, the authors examined the influence of prior elaboration on the search topic on children's website selection. Eighty-eight students were randomly assigned to two conditions. In an "Elaboration" condition, the children had to first read a text elaborating on the search topic and to answer a comprehension about this text before actually start searching. In the control condition, children directly engaged in the search task. In each condition, the authors also distinguished between good and poor readers based on a reading fluency test. The search task was composed of 10 search topics presented on a computer screen. Each topic included a search phrase (e.g., "The highest mountains of the world") and a simplified search engine list displaying 16 website titles. Each website title contained two or three keywords from the search phrase with half of the titles being semantically relevant (e.g., "All the highest mountains") and half being not (e.g., "Highest cathedrals in the world"). The children were asked to select the four most relevant websites for each search topic. A trial was considered successful if the participants indeed

correctly select the four relevant websites. The “Elaboration” condition indeed improved good readers’ selections of relevant websites but had no significant impact on poor readers’ selections. In sum, the pre-search elaboration task, which itself was based on reading, was only effective for children with a higher level of reading fluency.

Based on previous studies conducted by Llorens and Cerdan (2012) or Cerdán, Gilabert, and Vidal-Abarca (2013) with older readers, Ayroles *et al.* (2018) recently proposed a short intervention study to enhance 5th graders' task model construction and to investigate whether a better task model indeed enhances children's ability to locate information in texts. In this study, 37 participants had to answer a series of questions by searching on a one-page, 6-paragraph document displayed on the screen of an eyetracker. All questions involved the location of a specific piece of information within a single paragraph (see also Potocki *et al.*, 2017 for a similar methodology). The children were randomly assigned to one of two conditions. In an “enhanced task model” condition, after reading each search question but prior to engaging in search, the participants were asked “what do you have to search to answer this question?”. In a control condition, the children were asked “Is the word xxx present in this question?”. The impact of this manipulation was examined in terms of children’s correct responses, response time and search strategies (by analyzing eye-tracking data). Participants in the “task model” condition obtained higher scores than those in the control condition. However - and unexpectedly - the authors observed no differences between “task model” and control conditions in terms of response time nor reading strategies (i.e., time to explore relevant vs irrelevant paragraphs; first fixation on relevant paragraph, etc.). Thus, making children elaborate the question demands had positive effects on their performance but did not lead them to search more rapidly nor to modify their actual search strategies.

Finally, other studies, not specifically focused on interventions *per se*, bring nonetheless interesting elements as regards the way “pre-search” activities could improve children’s search skills. For example, Raphael and McKinney (1983) made fifth- and eighth-grade children reflect on whether the answer to the question posed to them were “right there; think and search; or on my own” (i.e., awareness about the fact that the answer was either explicitly stated in text, implied by text, or can be found in the individual's knowledge base). The authors did not test however the impact of such intervention on children’s search skills but found relatively positive effects on more classical reading comprehension measure (i.e., correct responses to questions presented after the reading of the texts). An exploratory study conducted by Kammerer and Bohnacker (2012) also provides interesting insights into interventions that could focus on improving children’s use of relevant keywords in search engines. The authors asked 8- and 10-year-old students to conduct a set of search tasks using a search engine. For each task, they analyzed the queries typed into the search box, the time taken to complete the task, and also recorded browser activities (i.e., typing, clicking, scrolling, etc.) as well as children’s eye movements during the search. In general, the use of keyword lists was not beneficial for the participants, as they found more relevant information and did so more efficiently by typing the entire question in the search box. The authors therefore concluded that “children succeed better using their own strategies than trying to apply adult strategies” (p. 187). This result has important implications in terms of knowing what prerequisites are needed for children to enhance their search queries. An example is readers' awareness of text structure. Meyer and Ray (2017; see also Williams, Hall, & Lauer, 2004) recently reviewed empirical studies on text structure interventions for elementary school students. They showed that such interventions were beneficial to improve expository text comprehension and knowledge of text structure. However, we do not know so far whether such training on structure strategy could indeed lead to better information search strategies in children. Such an investigation could be explored in future works.

In sum, interventions using pre-search activities may improve the quality of children's search outcomes. However, these interventions do not result in better research strategies *per se* (Ayroles *et al.*, 2018) and seem only beneficial for some readers (Coutelet & Rouet, 2004; Rouet *et al.*, 2011). Other studies have therefore also developed interventions focused on later steps of information search activity such as processing of the documents and an evaluation about their relevance and reliability.

3.2. Interventions focused on selecting and evaluating document information.

Studies focused on the training of information selection have mostly focused in issues of information quality and reliability. In contrast with studies targeting older readers (adolescents, or young adults; see for example, Brante & Strømsø, 2018), research focusing on elementary school children is still scarce. One study by Macedo-Rouet, Braasch, Britt, and Rouet (2013) attempted to raise 4th and 5th grade students' (9-10 years of age) awareness of source attributes and information evaluation based

on these attributes. Ninety-six students were either assigned to an experimental group or a control group. The experimental group attended a one-session intervention (30 minutes) consisting of mediated discussion in small groups. After making children think and discuss of the reasons to accept or reject someone's advice or opinion, the session involved the reading of a small text containing two characters which had opposing views about a specific topic. The characters were introduced through their professional occupation (e.g., veterinarian) or personal traits (e.g., young lady who loves dogs as pets). The professional occupation implied that the character was a specialist on the domain, whereas the personal trait suggested an interest but no specific qualification or expertise in the topic. The general goal of this session was to encourage children 1/ to identify source parameters in texts ("who is Louise?"), 2/ to establish links between sources and content (i.e., "who said what?"), and 3/ to assess the knowledgeability of each source as regards the topic at stake in the text (i.e., "who is the more knowledgeable on this topic?"). A discussion about the notion of knowledgeability, differences between non-expert and expert authors, the necessity to take into account different perspectives and to refer to the source of information was led by the experimenter with the children. In the control condition, children performed a series of reading comprehension tasks (i.e., reading of short texts followed by comprehension questions). To examine the effect of this intervention, participants had to complete before and after the intervention a source evaluation task in which they have to remember, after the reading of four short texts, the source of an information and to identify "the more knowledgeable" character of each text. By contrasting the performance of good versus less-skilled comprehenders, Macedo-Rouet et al. found that the intervention was beneficial for less-skilled readers only. This result contrasts with Rouet *et al.*'s (2011) intervention (based on the reading of a short text) whose benefits were observed for better readers only. Macedo-Rouet et al. therefore argued that the specific format of the intervention provided (i.e., spoken modality, small groups and interactive discussion) may have been particularly beneficial for less-skilled comprehenders.

In sum, studies focusing on the processing of documents and their evaluation in terms of reliability brings promising results in enhancing children's evaluation skills. Such processes have also been targeted in studies conducting more "comprehensive" interventions encompassing different stages of functional reading and information search.

3.3. Interventions combining several stages of the information search processes.

Most instructional interventions published thus far have combined activities targeting different steps of information search processes in order to foster children's functional reading abilities (Table 2).

Table 2. Instructional objectives identified in a set of intervention studies and correspondence with the three core challenges of information search (see Table 1).

Study	Building a task model	Accessing information	Assessing adequacy and sufficiency
Kuiper <i>et al.</i> (2008)	Not explicitly addressed in training plan	Search for Web information Read and interpret Web information	Assess and evaluate Web information
Zhang and Duke (2011)	Have a plan, write a to-do list	Know how web site is organized	Check source (who, why, when written) Check whether information helps meet search needs
Kingsley <i>et al.</i> (2015)	Not explicitly addressed in training plan (1)	Locate information	Evaluate and synthesize information
Gerjets and Hellenthal-schorr (2008)	General knowledge of information problems (Module 2) Break complex problem into subproblems (Module 6)	Know the Web as an information environment (Module 1) Localize Website (Module 4) and information within Website (Module 3) Select an information provider (Module 5)	Not explicitly addressed in training plan.

(1) Kingsley *et al.* did stress the importance of generating questions as part of the goal of locating information.

Kuiper, Volman and Terwel (2008) evaluated the impact of an educational program conducted by four 5th grade teachers that aimed at fostering Web search skills. The program was composed of eight weekly sessions (1.5-2h each) and tapped different aspects of functional literacy such as locating information and evaluating document information (see Table 2 below). All activities were based on the single topic of healthy food. The authors collected a variety of data, mostly qualitative (e.g., lesson observations, interviews with teachers and students, teacher diaries, student questionnaires) and also examined the impact of this intervention on children's Web search skills. The results were promising as regards the possibility of making usual classroom-teachers implement this type of interventions in their educational program. However, the study remained inconclusive as regards its impact on children's functional reading skills. For instance, the intervention did not influence children's search behavior in a non-supervised Web search activity, and only two of the four participating classes showed progress in their evaluation skills. Zhang and Duke (2011) proposed a longer intervention (4 times 30 minutes) in which 4th and 5th graders were trained on information evaluation using a framework called WWWDOT. This framework was designed to enhance children's critical evaluation of information by encouraging them to reflect about at least six aspects about a document (see Table 2 above). Paired randomization was used to assign the 242 participants of the study to either an experimental or a control group. The children in the experimental group attended four sessions of 30 minutes in which they were taught the WWWDOT lessons in their classroom. The control children followed their usual teaching program. Different tasks assessing source evaluation skills were administered before and after the interventions to all the children: a questionnaire, a single website evaluation task, and a website ranking task. The results obtained in the questionnaire showed that the WWWDOT framework made children more aware of the need to evaluate information for credibility on the Internet, for example by making them more aware of the existence of untrustworthy information. As regards the two website evaluation tasks, children in the experimental group were not better in the reliability judgment scales but justified their reliability scoring using more source-based reasons.

Kingsley, Cassay and Tancock (2015) conducted a quasi-experimental study with 418 5th graders and obtained more conclusive results as regards the ability to enhance elementary students' online research skills. In this study, they compared an 8-week intervention to a control condition and made use of several quantitative indicators of potential benefits of their intervention (Online Research and Comprehension Assessment – ORCA - Elementary-Revised performance, Leu, Kulikowich, Sedransk, & Coiro, 2009). The instructional framework selected in this study was the Internet Reciprocal Teaching (IRT) Model (Leu *et al.*, 2005; Leu & Reinking, 2010). The intervention program comprised 13 lessons spread over 8 weeks and were conducted within the classrooms using laptops. These lessons addressed three major aspects of information search: 1/ Locating information (e.g., navigate within websites, internet-specific vocabulary, self-generated questioning, effective key wording, etc.); 2/ Critical evaluation (questioning the author, checking information accuracy, bias detection, etc.); and 3/ Synthesizing (e.g., synthesize information from inquiry research, use of online concept mapping, etc.). Following the Reciprocal Teaching framework (Palincsar & Brown, 1984), the training sessions alternate between lesson, practice (guided or not) and discussion times. Children in the control condition continue to follow their typical instructional activities. After controlling for children's "traditional" reading skills, the results demonstrated that the intervention group showed significantly higher gains from pretest to posttest on the online research measures. More precisely, by distinguishing between three subscales of the ORCA test, the authors reported that these differences concerned the online skills of locating and synthesizing, but no significant group differences were observed for growth in the domain of critical evaluation skills. Authors also observed that the children with higher skills in traditional reading activities demonstrated greater gains after the intervention on the online research tasks.

Finally, Gerjets and Hellenthal-Schorr (2008) developed a web-based training for children (CIS-WEB, Competent Information Search in the World-Wide WEB, see also Schorr, 2005) which aims at fostering knowledge and skills necessary for efficient information search on the web. Interestingly, they compared its effectiveness over a conventional technically-oriented Internet training ("Surfcheck- Online") or an unguided exploration of the web. The CIS-WEB program consisted of six training modules (12 sessions of 45 minutes each) that combined direct instruction and individual and/or dyad practice and used a problem-solving training approach. The training modules addressed issues from basic knowledge about the WWW to more complex strategies to locate relevant information on a website or evaluate information with regard to its credibility and actuality. The results showed that neither the conventional Internet training nor an unguided exploration of the web were helpful to improve children's search performance. In contrast, the CIS-WEB training substantially improved participants' declarative knowledge as regards search-irrelevant versus search-relevant

information and also increased their performance in information problem solving using the Internet. The authors noticed that such positive effects were visible from the end of the 1st training module (i.e., after three training sessions only), whereas further improvements seem to depend on children's investment in the worksheets and exercises embedded in the training.

3.4. Summary and perspectives for future intervention studies.

In conclusion, the studies presented in this section provide promising evidence as regards the possibility to foster children's information search skills through adequate interventions. The studies conducted so far have either targeted specific processes at work in information search or offered interventions aimed at fostering simultaneously several processes and steps of information search.

Specific interventions aimed at having the children develop a better task model (e.g., "what am I looking for?"; "how can I access effectively relevant information depending on what I am looking for?"), or assessing the relevance of information (e.g., "is the information found relevant and reliable?"). Although the evidence is still scarce, it seems that these interventions may have positive effects: trained students showed better mastery of the targeted processes. However, we also noticed that the effects of these interventions were sometimes confined to certain types of readers (e.g., good readers, Rouet *et al.*, 2011, or younger readers, Coutelet & Rouet, 2004) or concerned only some measures but not others (e.g., Ayroles *et al.*, 2018). The promising point here is that these studies usually consisted in relatively short interventions (sometimes a single 30-minute session, Macedo-Rouet *et al.*, 2013, or even a specific prompt given at the time of the search, Ayroles *et al.*, 2018). It remains to be found whether more substantial interventions would expand these benefits.

The latter studies have attempted to develop more comprehensive interventions aimed at fostering simultaneously different information search processes. These studies combined an instruction both at the level of relevant information localization, its evaluation in terms of reliability or credibility, and the synthesis of information found in different documents (or websites). These studies, which involved longer intervention times (generally spread over several sessions), also yield overall positive conclusions. In addition, such interventions, based for the majority on didactical principles already used for the teaching of "traditional" reading comprehension skills (e.g., reciprocal teaching, Palincsar & Brown, 1984), seems to be more effective than a simple use of the Internet or than interventions centered on more "technical" aspects of online reading (Gerjets & Hellenthal-Schorr, 2008).

Some of the aforementioned studies also showed that this type of interventions could well be implemented in classrooms by regular teachers (Kuiper *et al.*, 2008). This point is of particular interest given that most countries have now such expectations about information search skills in their school curricula (for example in France, with issues relating to media education). Nevertheless, teachers often lack definite content on how to teach functional reading skills to children and we believe the studies presented in this chapter could provide some interesting insights into both the processes that can be targeted in such instructional sessions and the activities that could be proposed to children in order to enhance the use of these processes.

4. Conclusions

In this chapter, we have examined children's acquisition of information search skills as they apply to printed and digital texts. Text search is a complex form of reading that involves a series of cognitive and metacognitive processes. Based on a review of theories stemming from information science and psychology, we have highlighted three core processes that may pose specific challenges to developing readers: Forming and maintaining an adequate mental model of the task, accessing relevant information, and assessing the quality and sufficiency of information with respect to the task goal (or product). We have reviewed evidence that children between the ages of 7 and 12 indeed experience difficulties with these processes. Finally, we have reviewed the literature regarding instructional interventions focusing on search skills.

Despite a sustained interest dating back from the 1980's, information search as a complex skill is still an under-researched area. Furthermore, the domain itself has evolved dramatically with the advent and widespread dissemination of digital reading environments. Different perspectives can be identified and could be explored in future works, in reference to the three core processes elicited in this chapter. For instance, few studies have been conducted to improve children's ability to construct and handle search task models (Rouet & Britt, 2011). Beyond studies prompting students to think

about the question (Ayroles *et al.*, 2018), one could consider interventions targeting the different dimensions of the task model such who is asking and why? In what context do I perform this task? for which purpose? (see Britt *et al.* 2018); the type of response that can be expected (a "single" response located in a specific part of the text, such as a specific date or a single word, or an answer that will require searching for more information located in several parts of the text or even, in several documents); or the potential location of the searched information within the documents. Interventions could also focus on document structure, and in particular the use of organization and content cues in websites to access more efficiently the searched information.

Systematic work aimed at training students' information search can and should also be undertaken with elementary and secondary school students. Research conducted so far does provide interesting hints, but studies carried out with older readers (e.g., Brante & Strømsø, 2018; Pérez *et al.*, 2018) could also serve as a basis for the development of future interventions with younger students. However, as the aforementioned study by Kammerer and Bohnacker (2012) pointed out, caution is needed in applying adult search strategies to children. Interventions designed for children should take into account their actual potential and limitations (for example, by favoring oral discussion over the reading of written explanations; see Macedo-Rouet *et al.*, 2013). Learning to effectively search information is also related to other dimensions of children's language and cognitive development. For instance, children's acquisition of vocabulary is critical for their use of search engines, as querying rests on an ability to flexibly generate and refine verbal expressions in relation to a search need. Finally, strategies for reading multiple documents and integrating integration from multiple documents (including how to handle inconsistencies and contradictions) must be an important point to work with young students. This type of situation is indeed very common in the reading activities children carry out on a daily basis, whether in the school context or in their daily life. Generally speaking, the acquisition of effective functional reading strategies cannot be reached without going through an explicit teaching of such strategies. In order to benefit all students – whatever is for example their level in "traditional" reading comprehension - such interventions would ideally be adapted to the student's initial level and knowledge.

5. Author note

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